standing and he said, "I thought you told me to keep everything true and in a straight line. Now, why don't you do that yourself?" I asked him to explain what he meant and, pointing to a row of slope stakes which I had placed the day before, he said, "Cast your eye over those stakes. Are they in a straight line?" Of course, I could do nothing but throw up my hands in disgust.

You have all, no doubt, had similar experiences; likewise, you have had charge of many projects which have run smoothly from start to finish. We all strive to get good work. If the work is of a public nature. we endeavor to work in harmony with the other public officials and with the contractor and, at the same time, try to get work done that will receive favorable comment from the general public. When we accomplish these things, we are usually rewarded with a feeling of self-satisfaction over a job well done.

CONSTRUCTION PRACTICES ON CITY STREETS

By S. W. Hodgin, City Civil Engineer, Richmond, Indiana

In presenting this paper on construction practices on city streets, it is not the thought that a treatise on such work will be offered, nor that the practices discussed necessarily will be the best, nor a sort of ne plus ultra in street work. My efforts will be directed solely toward explaining the practices that have been in effect in my own city of Richmond. Some of these practices have been followed for many years and have proved their worth, while others are new and experimental only.

Richmond is a city of 33,000 population, with about 88 miles of streets, divided as follows:

Asphalt, 5 miles; brick, 7 miles; concrete, 16 miles; bituminous macadam, 5 miles; waterbound macadam, 20 miles; gravel, 22 miles, and unimproved, 13 miles.

With the exception of the very heavy traffic in the nine state highway routes within the city, the traffic on the improved streets is very uniformly divided and moderately heavy. As to their condition, I believe our streets are above the average for cities of Richmond's class and show the result of economic maintenance and consistent construction programs.

Before 1891, practically all of the usable streets of the city were of untreated gravel. Beginning with that year, a street improvement program was started and has been carried out religiously ever since, until, at the present time, 85 per cent of all streets are paved.

The cost of such improvements is now assessed against the abutting property in accordance with the Barrett Law. Rich-

mond, being a third-class city, is permitted to assess all of the improvement against the affected property, or the city as a whole may assume a part of the cost. In some cases the city has paid for the intersections. The decision as to the city's assuming any of the expense lies with the board of public works and is influenced by the importance of the street to be improved and value of the property benefited.

At least three types of pavement are advertised and the type selected is left to the choice of the affected property owners. How that choice is influenced depends to a great extent upon the skillful salesmanship of the materials' representatives.

RECONSTRUCTION OF GRAVEL STREETS

Since construction problems are so similar and the work is usually done by contract, it would be impossible to add much information of interest by describing our construction practices. These are well defined by law and must be followed. However, there is one form of reconstruction of gravel streets which was followed at one time that might come under the head of construction work, inasmuch as the work is somewhat more elaborate than ordinary surface treatment. Several years ago many worn-out gravel roadways were so rebuilt. In each case the surface of the roadway was scarified to a depth of about 3 inches, and 5 inches of new, bank-run gravel added. This was thoroughly harrowed, shaped, wet, and rolled to the desired crown and finish. With the final rolling, the surface was brushed by means of a steel brush attached to the roller, thus filling the voids in the larger aggregate and giving the surface a smooth finish. Before further treatment was given, the roadway was permitted, if possible, to stay open to traffic until the succeeding year in order that it might be thoroughly compacted.

After thorough compaction under traffic, all depressions were filled with patch material and the proper contour of roadway re-established and surface swept clean. Following surface preparations as above, the roadway was treated with cold Tarvia B by means of a pressure distributor. For the first treatment, about ½ gallon per square yard was applied and, after a short time for setting, the street was thrown open to traffic. After the entire roadway had become well compacted by traffic, a second application of about ½ gallon of Tarvia B was made. In most cases a covering with a moderate amount of chips or pea gravel was applied after the second application.

Streets constructed in this manner have been in use many years under moderate traffic and have given the utmost satisfaction. The first cost of this type of reconstruction was about 40 cents per square yard. The maintenance cost is very light. Personally, I doubt that this type of construction would be satisfactory or economical under heavy traffic conditions.

Our maintenance problems are many and present many interesting cases. About 42 per cent of our streets are either gravel or waterbound macadam. One seeing most of these streets now, however, would not recognize them as such. Prior to 1912, such streets were maintained as originally constructed, either by the addition of gravel or by scarifying and re-rolling the macadam. They would become, of course, very dusty and require frequent sprinkling in the summer time to allay the dust nuisance. To overcome this nuisance, the practice of treating the roadway with road oil was started. This work was first done under petition of the residents of any particular street and was paid for by subscriptions from such petitioners. Such treatment acted only as a dust palliative and frequently resulted in the street's getting into worse condition than had nothing been used. The oil seemed to destroy the actual bonding quality of the gravel and, in wet weather, formed an objectionable, greasy mud.

About 1917 was started the practice of surface-treating our gravel and waterbound macadam streets with the higher grade bituminous materials. The streets first treated were those that had been built and used for many years and had therefore become well compacted so that it was not necessary to build a base.

The first treatment, similar to the construction described above, was, and still is, to shape the untreated roadway to proper contour, filling all holes with patch material, cleaning the surface of dust and applying, with pressure distributor, a penetrating bitumen in sufficient amount to form a moderate depth of coated material, usually from ¼ to ½ gallon per square yard being used. On this surface, after blading or dragging if necessary, are spread stone chips or pebbles in an amount of about 10 pounds per square yard. In some cases, after a short time the street is thrown open to traffic as above treated. In others, it is found desirable to blade or drag the roadway again and give the surface a second treatment with a lesser amount of bitumen.

MAINTENANCE REQUIRED

After a gravel or macadam street has been treated as above, it must be surface-treated periodically as conditions may require. The period of retreatment varies from 2 to 5 years, depending upon the condition of the original base and the traffic handled. For this resurfacing the general practice is to clean the paved surface thoroughly and apply about 10 pounds of stone chips or pea gravel per square yard. On this is applied, from a pressure distributor, from 0.15 to 0.25 gallon per square yard of bituminous materials, heated to proper temperature varying from 200 to 300 deg. Fahr. In some cases, the stone chips are spread after the application of bituminous material. The latter method has some advan-

tages, in that traffic may be admitted within a short period without the surface being picked up. The first method appears to give a better coating of the chips. This maintenance treatment costs from 4 to 6 cents per square yard or about 1½ cents per yard per year.

A majority of our streets are so treated and are always in practically as good condition as our paved streets. Treating the roadways more frequently with a minimum amount of bitumen seems to keep the street in better condition at all times than heavier applications at less frequent intervals. By following this practice no trouble has been experienced with surface corrugations.

During the past few years, we have done considerable resurfacing of old pavements that had gotten very rough or were disintegrating under traffic or from weather conditions. With this class of work we are still experimenting and I am frank to say we have not yet decided upon the 100 per cent job.

RESURFACING

That portion of Main Street from East Fourth Street to East Twentieth Street, a distance of about 6,000 feet, was paved with brick in 1892 and 1893. This street is a part of State Highway No. 40. Standard Canton paving blocks were used and laid on an eight-inch stone base, the pavement extending over a double track electric railway. The original pavement cost was assessed against the abutting property, the city paying for the intersections. The brick surface had served its life and had become rough, because of broken and sunken bricks, and was very expensive to maintain. A life of thirty-eight years for this type of pavement indicates excellent initial workmanship and firm foundation, but on account of the rough surface, it was deemed necessary to improve it.

After much consideration as to what should be done and how payment should be made, it was decided this year that the existing pavement should be retained, patched where loose, and the entire surface covered with an average of about 1¼ inches of surfacing material. The work was to be done by the street department and paid for out of its budget money. The original program was that only a portion of the street, as determined by the funds available, would be surfaced by applying ¾ inch of hot asphalt plant-mix, made by a local contractor, and this covered with ½ inch of rock asphalt.

The rock asphalt is, of course, well known and needs no description. The plant-mix consists of asphalt-coated No. 6 stone chips or crushed gravel, dried and heated to a temperature of about 350 deg. Fahr. The asphalt that proved most successful was Trinidad Lake heated to about 300 degrees. The mixing of the asphalt and aggregate is done in a pug mixer, a small amount of limestone dust being added to each

batch as filler. The hot-mix was hauled to the job from the plants in trucks covered with tarpaulins to conserve the heat.

First the pavement was thoroughly cleaned and painted with a coat of emulsified asphalt. Three fourths of an inch of the plant-mix was then spread, at a temperature of about 200 degrees, raked to proper contour, and thoroughly rolled. On this the ½ inch of rock asphalt was spread and again rolled with the equivalent of about a 7½-ton roller.

This was done for only about one-fourth the entire length of the street, since, with the funds available, it could not be completed without materially curtailing other street work. The work proved so satisfactory to the public generally that there was a demand that the entire improvement be completed this year. Funds for the entire improvement with the rock asphalt top could not be raised. However, the plant-mix was applied for the entire stretch and the street thrown open to traffic as soon as rolling was completed. One of the advantages of using plant-mix material is that any portion of the street need be out of service but a few hours.

This improvement, which cost $0.62 per square yard for the single course of hot-mix and $0.92 per square yard for the combined hot mix and rock asphalt, has been in service for seven months and gives evidence of being very satisfactory. Along the street car rail, where the surface material was feathered out to a thin layer, it is chipping off in a few places. This, however, was expected and these spots, as well as others which we anticipate, will be patched with rock asphalt as may be needed.

In 1916 there was built a concrete pavement under the three-mile road law which is now part of our street system. For the past three or four years, this pavement had been disintegrating badly, each winter adding to its destruction. In order to save it from further disintegration, it was decided to cover the concrete with a bituminous top, the work to be done jointly by Wayne County and city employees.

First a 4 inch layer of No. 2 stone was spread, shaped, and rolled to proper contour and compacted to about 3 inches. This course was 20 feet wide, though the concrete was but 18 feet. After rolling, the stone was penetrated with 1¾ gallons of tar Tm per square yard, chipped with No. 6 stone, and dragged until the voids were well filled. By the addition of more chips and cut-back asphalt, a total of about 2½ gallons of bituminous material per square yard was applied.

In order to close, or seal, the surface voids, a final application of 10 pounds per square yard of rock asphalt was made and this well rolled. This final treatment was very effective and produced a fairly smooth surface, without having the appearance of a rock asphalt finish. This pavement, part of which is now a state highway route, has been in service under

fairly heavy traffic for over a year and gives every evidence of standing up. The cost was $0.93 per square yard.

In 1926 brick pavements on Fort Wayne Avenue and North D Street, constructed in 1904 and 1911 respectively, were resurfaced with rock asphalt. The old pavements were first cleaned and given a paint coat of cut-back asphalt. On top of this was placed ¾ inch of rock asphalt, which was thoroughly rolled and compacted. In general, this resurface has been satisfactory, scaling off only over the street car tracks in the center of the street and in a few other spots where the brick pavement was not thoroughly dry and clean before the paint coat was applied. This resurfacing cost about $0.75 per square yard, the work being done by the street department.

About 10 years ago the Indiana State Highway Department rebuilt a portion of U. S. 40, the National Road east of the city, by the penetration method, applying from 8 to 12 inches of stone penetrated with the equivalent of A2 asphalt. The road was built to a crown of 15 inches in a width of 46 feet between curbs, with a single track traction line in the center. An excessive amount of asphalt was used, which resulted in bleeding and a very slippery surface in wet weather. This surface condition, with the excessive crown and traction line rails, presented a very dangerous situation. Many accidents occurred, through cars skidding, and finally a double fatality a few weeks ago. This stretch of road was taken into the city in 1929, the city thus falling heir to the problem of correcting the dangerous condition. Frequent applications of stone chips were made to this pavement in an attempt to establish a surface that was not slick. This was effective for a short time, but on account of the excessive amount of bituminous material, the stone was forced down and the surface again would become very slick. This treatment also increased the already excessive crown.

Had there been no standard concrete curbs and gutters, it would have been possible to build a top on the existing pavement and thus secure a nonskid surface. It was decided to scarify the surface and cut down the thickness of the penetrated stone course by about 3 inches and then construct a new surface that would not get slippery in wet weather. This was done by using a "rooter" to break up the penetrated stone base. The work being done in cold weather, the asphalt binder was brittle and crumbled readily. The 3 inch excess of stone was hauled away and applied to other roadways where it could be used to advantage in base building. After being cut down to grade, the remaining coated stone was shaped to proper contour and rolled with a 10-ton roller until thoroughly compacted. The surface was then coated with emulsified asphalt in an amount of one gallon per square yard. On this was applied a 1 inch course of the plant hot-mix asphalt made by

the local contractor. After thorough rolling and sanding of the surface, this pavement was at once thrown open to traffic. This surface is as non-skid as it is possible to make and seems to have corrected the dangerous condition, no more trouble so far having been experienced. This work cost about $0.82 per square yard and in the aggregate will amount to about $1400. Payment is being made from the city's general fund by special appropriation of the council.

In resurfacing our pavements, we have attempted to do the work without destroying the old base. A base that has been compacted by years of use is as good as any that can be built new and certainly should not be disturbed without good cause. As stated in the beginning, we do not consider our work the last word and we are open to innovations and are willing to try anything once.

MAINTENANCE PRACTICES ON CITY STREETS

By J. V. Schneider, City Street Commissioner,
Richmond, Indiana

In reports published in some of the municipal journals, it probably has been noticed that the amount of money spent by the street department of Richmond is rather high as compared with other cities. Such figures are somewhat misleading. The total expense of our department is about $90,000 per annum. Of this amount, however, about $33,000, or 37 per cent, is spent for trash and rubbish collection, about $8,100, or 9 per cent, for street cleaning, and about $33,000, for street maintenance and repairs. The other work of our department consists in repairs to sewers, bridges, buildings, etc., and amounts to about 17 per cent of our total expense. Street maintenance is, of course, our most important work.

A large percentage of our streets are waterbound macadam or trafficbound gravel. By this latter I mean streets that have become compacted under traffic. These types present our greatest problem. They become rough, through chuck-holes and corrugations forming and from settlement of trenches made by the utilities. All streets are damaged by this latter work. We have an arrangement in Richmond under which the utility, or any person for that matter, must make a deposit with the city to cover the expense of repairs, before permission can be secured to cut into any improved street. The amount of the deposit is based upon the units of work to be done at rates determined by past experience and fixed by ordinance. After the utility or private persons have completed their work, the street repair work is done by the street department. The cost of this class of work, in the aggregate, amounts to a large sum; and while it is paid back to the city,